SHOCK HEATING AND SUBSEQUENT COOLING OF BASALTIC SHERGOTTITES: THE CASES FOR QUE94201 AND DHOFAR 378. T. Mikouchi[1] and G. McKay[2], [1]Dept. of Earth and Planetary Science, Graduate School of Science, University of Tokyo, Hongo, Tokyo 113-0033, Japan. [2]Mail Code SR., NASA Johnson Space Center, Houston, TX 77058, USA. (E-mail: mikouchi@eps.s.u-tokyo.ac.jp)

Introduction: Shock metamorphism is one of the most fundamental processes in the history of Martian meteorites. Especially, shergottites experienced strong shock effects (>30 GPa) most likely when they were ejected from Mars [*e.g.*, 1]. "Maskelynitization" of plagioclase and formation of shock melts are major effects due to this severe shock. QUE94201 (QUE) and Dhofar 378 (DHO) are basaltic shergottites that are mainly composed of pyroxene and plagioclase glass [*e.g.*, 2-3]. These two shergottites suffered severe shock, which generated abundant impact melt and vesiculated flow textures. In spite of similar degrees of shock between two meteorites, they are distinct in several mineralogical aspects. In this abstract, we discuss their differences to understand differences in their shock heating and subsequent cooling histories.

QUE94201: QUE is composed of subequal amounts of pyroxene (pigeonite and augite) and plagioclase glass. Plagioclase glass is isotropic and is similar to "maskelynite" in other shergottites. There is no area showing birefringence even where plagioclase glass is in contact with either shock melt or fusion crust. Plagioclase glass shows "normal" chemical zoning from An-rich core ($An_{65}Ab_{35}$) to relatively Ab-rich rim ($An_{59}Ab_{40}Or_1$). A wide shock melt vein cut across the center of the thin section studied (Fig. 1a). Several grains of plagioclase glass are entrained in this shock melt vein, and some show flow textures, suggesting melting of plagioclase (Fig. 1b). These plagioclase glasses are enriched in Fe (FeO = up to 6 wt%). In the shock melt vein, dendritic pyroxene grains (up to 100 µm long) recrystallized (some nucleated on pyrrhotite spherules of ~200 µm in diameter) (Fig. 1c). This suggests that pyrrhotite precipitated from the melt before the crystallization of pyroxene. Plagioclase recrystallization is not observed in the melt. The melt is enriched in P (P_2O_5 = ~7 wt%) although it is heterogeneous.

Dhofar 378: DHO is also composed of subequal amounts of clinopyroxenes and plagioclase like QUE, and contains abundant vesicles (~1 mm in diameter) (Fig. 2a). The sample shows the presence of many blackened areas similar to shock melt, but FEG-SEM observation revealed that they were composed of recrystallizing fine-grained pyroxene and plagioclase (Fig. 2c). The most notable difference of DHO from QUE94201 is seen in plagioclase mineralogy. Although some plagioclase grains display flow textures like QUE, plagioclase in DHO shows a fibrous crystalline texture (Figs. 2b and d). These plagioclase grains show dirty appearance with vesicles. The plagioclase composition ranges from $An_{60}Or_1$ to $An_{40}Or_7$, but most grains do not show clear chemical zoning in major elements. Some plagioclase grains include thin feldspathic glass bands located in the center of the grains (Fig. 2d). These feldspathic glass bands are up to a few tens of µm wide and are enriched in K (K_2O = up to 7 wt%). The presence of both recrystallizing plagioclase rims and the inner K-rich feldspathic glass areas is similar to experimentally reheated "maskelynite" in Zagami [4]. Plagioclase showing a flow texture is often intergrown with shock melt, which is composed of fine phases (probably pyroxene) (Fig. 2e).

DHO is most similar to Los Angeles in mineral chemistry as was pointed out by [3]. Pyroxene compositions nearly overlap each other. Another similarity includes the presence of Si-, K-rich feldspathic glass in the mesostasis. The only mineralogical difference of DHO from Los Angeles (except that plagioclase is isotropic glass in Los Angeles) is the absence of pyroxferroite breakdown products (now composed of fayalite, hedenbergite and silica) [*e.g.*, 5]. Probably, they were preferentially melted by shock and recrystallized. Some areas in DHO include euhedral fayalite with pyroxene and the mesostasis (Fig. 2f). These may correspond to the areas of originally pyroxferroite breakdown products.

Shock heating and subsequent cooling: The textural observations of QUE and DHO suggest that the degree of impact was similar between them, generating vesicular shock melt veins and melting plagioclase. Their difference is thus seen in the degree of recrystallization of the shock melt. In QUE, shock melt is partly composed of fine-grained pyrrhotite and pyroxene, but glassy areas are still present (Fig. 1c). In contrast, the impact melt-like areas in DHO are almost completely recrystallized and are mainly composed of fine-grained pyroxene and plagioclase. Pyrrhotite spherules are absent. Because of the similarity of the recrystallizing plagioclase in DHO to the experimentally reheated "maskelynite" [4], there is a possibility that DHO was originally shocked and maskelynite was already present. Then, it was somehow reheated on Mars causing recrystallization of maskelynite and another shock event ejected it from Mars. The other possibility is that DHO was ejected from Mars by strong shock, which generated shock melting of plagioclase.

Then, subsequent cooling from high temperature allowed partial recrystallization of plagioclase. Ikeda et al. [3] reported that their sample has a fairly large area of K-rich glass and the recrystallizing plagioclase rims are up to 100 µm wide. In contrast, most plagioclase grains completely recrystallized and such K-rich glass is rare in our sample. This shows heterogeneity of the degree of recrystallization in DHO even though it is a small meteorite (total mass: 15 g). Thus, it is unlikely that the reheating occurred on Mars by some endogenous heat source and produced such heterogeneity in centimeter scale. The heterogeneous cooling history in such a small sample is thus likely caused by shock event after the ejection from Mars. In DHO, the cooling was slow enough to allow recrystallization of plagioclase. In contrast, QUE experienced a similar degree of shock, but it cooled too rapidly to recrystallize plagioclase. Otherwise, the temperature increase of DHO was greater than QUE, which allowed recrystallization of plagioclase during cooling from high temperature.

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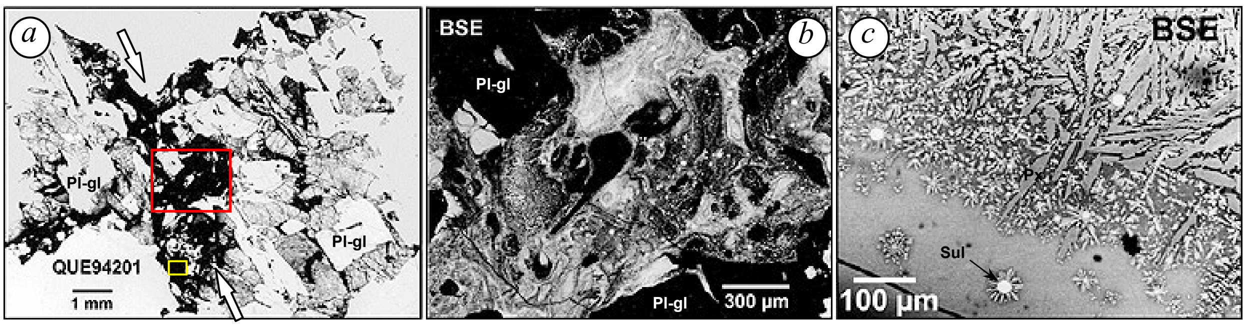

Fig.1. (a) Optical photomicrograph of QUE94201,34, showing the presence of impact melt (arrows). Pl-gl: plagioclase glass. (b) Backscattered electron image (BEI) of the area shown as a red square in (a). Note heterogeneous melt texture. (c) BEI of the impact melt area shown as a yellow square in (a). Note recrystallization of Fe sulfide (sul) and pyroxene (px) in the melt.

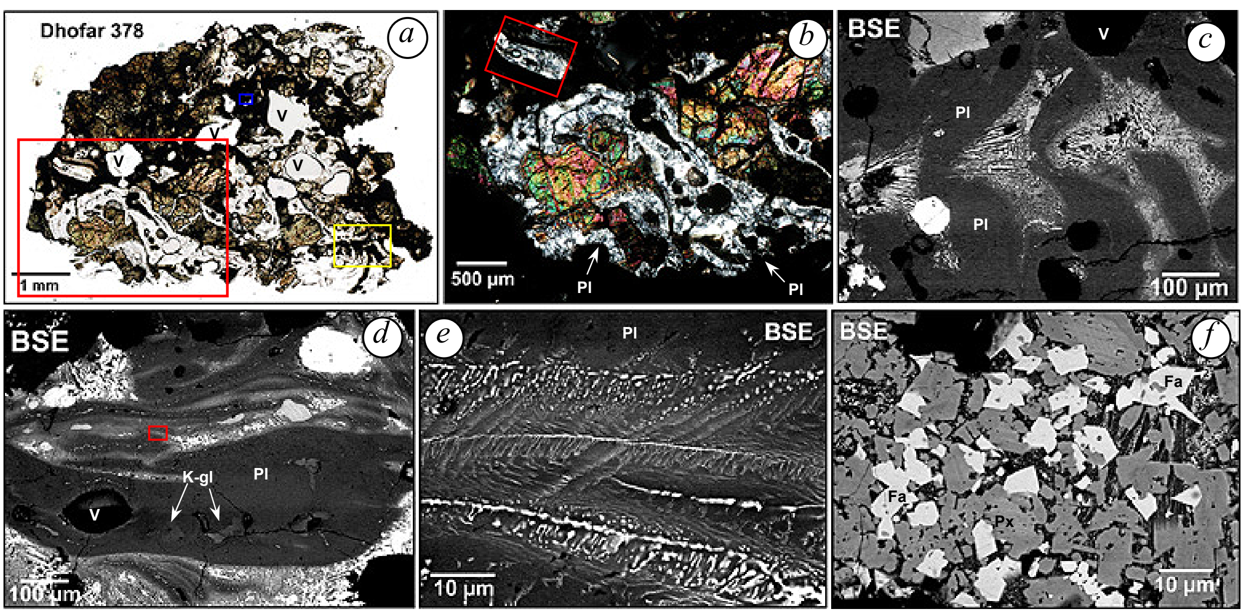

Fig.2. (a) Optical photomicrograph of Dhofar 378, showing a vesiculated texture. V: vesicle. (b) Optical photomicrograph (crossed nikols) of the area shown as a red square in (a). Plagioclase grains almost completely recrystallized. Pl: plagioclase. (c) BEI of the impact melt area shown as yellow square in (a). The impact melt-like areas are composed of fine-grained mixture of pyroxene and plagioclase. (d) BEI of the plagioclase grain showing a flow texture (shown as a red square in (b)). The plagioclase is partly mixed with impact melt veins. K-gl: K-rich feldspathic glass. (e) BEI of the area shown as a red square in (d). The impact melt-like veins are composed of fine-grained dendritic phases (pyroxene?). (f) BEI of the area shown as a blue small square in (a). Euhedral olivine and pyroxene are present.